

REMARKS

Reconsideration and further examination of this application is hereby requested. Claims 1-18, 20-28, and 33-42 are currently pending in the application. Claims 3, 16-18, and 22-27 have been withdrawn from consideration as being directed to non-elected species.

Claims 19 and 29-32 have been canceled. Claims 1, 4-6, 14, 17, 28, 33, and 37 have been amended. Claims 39-42 are newly added.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached pages are captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE".

A. The Interview

Applicant thanks the Examiner for the courtesy extended in the personal interview of July 31, 2002. In particular, Applicant appreciates the Examiner's constructive suggestions for improving the application by making language usage more consistent. Language of the claims and specification has been amended to substantially adopt the Examiner's suggestions. This is explained in detail later in these remarks.

Although no firm agreement was reached as to what would be allowable over the prior art, the undersigned did review various

distinctions between the invention and the applied prior art references. These distinctions are discussed in detail later in these remarks.

B. The Indefiniteness Rejection

Claims 1, 2, 4-21, and 29-33 have been rejected under 35 U.S.C. § 112, ¶ 2d as being indefinite because the Examiner is concerned that the terminology used is confusing and inconsistent. As suggested by the Examiner, the claims have been amended to overcome this rejection and the specification has been amended to be consistent with the amended language of the claims.

The specification and claims as originally filed refers to the "Faraday shield" structure of the present invention variously as being a "voltage distribution electrode," a "bottom layer," a "substrate" and some variations on those terms. During the interview the Examiner explained that she understands this structure to be a Faraday shield regardless of the other various terms applied to it. The Examiner suggested that a single term should be chosen to refer to this part of the invention and further suggested that the broadest alternative would be the term "Faraday shield." The Examiner expressed the view that the term "Faraday shield" encompasses within its meaning a "voltage distribution electrode." The Examiner also kindly requested that the term "substrate" not be used in the semiconductor art to mean

something other than the semiconductor work piece.

In order to advance prosecution, Applicant acquiesces with the Examiner's view of the terminology and has amended the claims and specification to clarify them by using more consistent terminology as suggested by the Examiner. Accordingly, Applicant respectfully submits that the indefiniteness rejection has been overcome by amendment.

C. The Objection to the Drawings

The drawings have been objected based on the Examiner's concern that not all claimed elements were being illustrated in the drawing figures. However, this concern was based on the Examiner's confusion about the terminology used to describe the Faraday shield aspect of the invention. See part B of these remarks, above.

Because the meaning of the terminology regarding the Faraday shield aspect of the invention has been clarified by amendment, Applicant respectfully submits that there need not be any concern about the completeness of the drawings. All claimed elements are illustrated in the drawings. Applicant respectfully submits that this objection to the drawings is moot in view of the clarifying amendments to the specification and claims.

D. The Obviousness Rejection

Claims 1, 2, 4-15, 19-21, and 28-38 have all been rejected

under 35 U.S.C. § 103 as being obvious over Guo et al. (U.S.P. 5,944,899) in view of Yoshida (U.S.P. 5,735,993), Okumura et al. (U.S.P. 6,177,646), and Rice et al. (U.S.P. 6,095,083). The claims have been amended. In view of those amendments to the claims, the obviousness rejection is respectfully traversed for the following reasons.

In order for a patent claim to be obvious, the prior art must teach or suggest each and every limitation of that claim. That is because the claim must be considered as a whole - it may not be distilled down to a "gist."

Independent claim 1 (as amended) recites a combination of a heating element, a Faraday shield, and a semiconductor processing chamber, that includes the limitation that

the Faraday shield is disposed between the heating element and the chamber wall.

See lines 9 and 10 of claim 1. Independent apparatus claim 28 (as amended) recites a similar limitation at lines 10 and 11. Independent claim 6 (as amended) recites the limitation of

a resistive heating element layered over the Faraday shield adjacent to the edges of the Faraday shield

at lines 6 and 7.

The Guo et al. reference and the Rice et al. reference provide no suggestions concerning a Faraday shield or a heating element, and the Examiner does not contend that they do as they

were cited for other reasons.

The Yoshida reference discloses structure embedded inside the chamber ceiling that has functionality that corresponds to that of a Faraday shield and a heating element. The embedded structures of Yoshida are certainly distinct from the relationship of elements lain one atop the other as recited in the claims. Certainly Yoshida does not suggest the claimed configuration.

The Okumura *et al.* reference discloses structures that heat and shield. However, the solution proposed by Okumura *et al.* takes the art in a very different direction than the solution discovered and claimed by Applicant. Okumura *et al.* teaches that it is important to electrically shield the heating element. Thus, Okumura *et al.* discloses the heating element as being entirely surrounded by a metal encasement. In contrast, the present invention layers the unshielded heating element over a Faraday shield atop the chamber wall. To modify the structure of Okumura *et al.* to be consistent with the claimed structure would be contrary to the express teachings and intent of the Okumura *et al.* reference itself.

In view of the lack of a suggestion to make the modifications to the prior art that would be necessary to meet the limitations of the claimed invention, and further in view of

the explicit prior art teachings contrary to such a modification, Applicant respectfully submits that obviousness does not lie in this case.

For the above reasons, Applicant respectfully requests that the Examiner carefully reconsider and withdraw the obviousness rejection of claims 1, 2, 4-15, 19-21, and 28-38.

E. Affirmation of Species Election - Rejoinder of Claims

Applicant hereby affirms the election of Species I.

Applicant notes that, although the Examiner states that only claim 1 is generic, the claims appear to have been examined based on the treatment of claims 1, 4, and 28-38 as being generic. It is Applicant's belief that the Examiner acted correctly in treating claims 1, 4, and 28-38 as being generic. Since the election of species requirement appears to have been fairly applied (as examined), Applicant makes no traverse of the election of species requirement.

For the reasons set forth above in these remarks, Applicant believes that the pending claims (as amended) are allowable. Applicant respectfully asks the Examiner to review the propriety of rejoining claims directed to the non-elected species, in view of the allowance of any of the generic claims.

F. Closing

In view of the above, Applicant respectfully submits that

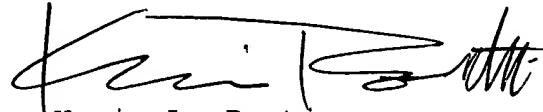
independent claims 1, 6, and 28 are patentable over the prior art. Applicant further submits that dependent claims 2-5, 7-18, 20-27, and 33-42 are patentable, at least as being dependent from patentable independent claims, and are further patentable due to the additional limitations recited therein.

For the above reasons, Applicant respectfully submits that the application is in condition for allowance with claims 1-18, 20-28, and 33-42. If there remain any issues that may be disposed of via a telephonic interview, the Examiner is kindly invited to contact the undersigned at the local exchange given below.

The Director of the U.S. Patent and Trademark Office is authorized to charge any necessary fees, and conversely, deposit any credit balance, to Deposit Account No. 18-1579.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Amend paragraph no. 11 as follows:

11. It is another aspect of the present invention to provide an integrated heater and [voltage distribution electrode] Faraday shield assembly arranged on the surface of a plasma chamber lid.

Amend paragraph no. 20 as follows:

20. The bottom layer of the heater assembly according to the resistive heating embodiments is preferably constructed from a material that has good thermal conductivity such as aluminum or copper, so as to serve as a Faraday shield. A resistive heater wire (such as Nichrome wire) is attached to the Faraday shield bottom layer without being electrically connected thereto and is wound along the radial segments and connective circular loop in a manner which maximizes the electromagnetic resistance (i.e., impedance) of the overall heater wire circuit to the electromagnetic fields produced by the coil. A layer of thermal insulating material is placed on the surfaces of the heater elements. This insulating material improves the efficiency of the heater by minimizing heat losses to the ambient air. This insulation is particularly helpful for the embodiments that

utilize forced air convection in order to remove excess heat from the surface of the dielectric lid.

Amend paragraphs nos. 37-39 as follows:

37. According to some embodiments, the present invention is embodied as a heating element, a [voltage distribution electrode (including a] Faraday shield[]), and a processing chamber in combination with one another. The heating element may be embodied using either fluid (as a conduit for a thermal working fluid to flow through) or electricity (as an electrical heating element).

38. According to other embodiments, the present invention is embodied as a temperature management apparatus for promoting thermal uniformity for a chamber wall using electricity. The apparatus includes a [substrate] supporting layer and a resistive heating element. The [substrate] supporting layer has a predetermined shape and has edges. The resistive heating element is disposed on the [substrate] supporting layer adjacent to the edges of the [substrate] supporting layer. The [substrate] supporting layer is adapted to provide thermal communication between the resistive heating element and the chamber wall.

39. The predetermined shape is selected so as to promote even distribution of heat energy over the chamber wall. Preferably

the predetermined shape has substantial radial symmetry.

According to one embodiment, the [substrate] supporting layer is shaped to have plural radial elements and a circular element, disposed at the periphery of the [substrate] supporting layer, that joins the plural radial elements together. According to another embodiment, the [substrate] supporting layer is shaped to have plural radial elements and a circular element, disposed near the center of the [substrate] supporting layer, that joins the plural radial elements together. According to either of these embodiments, the circular elements employed are interrupted by at least one gap formed therein. Preferably the [substrate] supporting layer is electrically conductive so that it forms a [voltage distribution electrode] Faraday shield.

Amend paragraphs nos. 44-46 as follows:

44. Such an apparatus according to the present invention for processing semiconductor wafers also may include an RF coil and a [voltage distribution electrode] Faraday shield. The RF coil is disposed adjacent to the vacuum chamber so as to couple RF energy into the vacuum chamber. The heater is disposed between the RF coil and the chamber wall. The [voltage distribution electrode] Faraday shield is disposed between the heater and the chamber wall. Preferably, the heater is substantially electrically

transparent to the RF energy coupled into the chamber.

45. Rather than a [voltage distribution electrode] fixed-shape Faraday shield, such an apparatus according to the present invention for processing a semiconductor wafer is optionally embodied with a Faraday shield having variable shielding efficiency. The variable efficiency Faraday shield is disposed between the heater and the dielectric wall.

46. A Faraday shield [is generally understood in the art to be a layer or plate of conductive material disposed between the RF antenna and the lid of the chamber electrically connected (at least indirectly) to ground. A voltage distribution electrode] is generally understood in the art to be a layer or plate of conductive material disposed between the RF antenna and the lid of the chamber, that is either connected to ground or is electrically floating. Some persons working in this art may refer to such a shielding structure as being a "voltage distribution electrode." [Thus, a voltage distribution electrode] As meant in this application, a Faraday shield is considered to be a general concept that encompasses within its scope a [Faraday shield] voltage distribution electrode, as well as other conductive electrodes regardless of how they relate to the system electrically.

Amend paragraph no. 54 as follows:

54. A resistive heating element 200 follows a path on the circularly-shaped dielectric lid that provides for an even heating of the lid. The resistive heating element 200 rests atop [substrate] supporting layer 205 that is shown in phantom. The arrowheads along the resistive heating element 200 illustrate flow of electricity. Preferably, the wiring pattern is embodied so as to have a continuous path that provides for current flow in both directions (i.e., both forward and back) along each of the radial segments and the connecting arcuate portions. The reason for the consistent juxtaposition of conductors with current flowing in opposite directions is so that their electromagnetic fields will cancel one another out.

Amend paragraph no. 56 as follows:

56. The partial cut-away portion of the view (in the lower right quadrant) shows the top layer of foam insulation 307 stripped away to expose the heater wire 309 resting on the [substrate] supporting layer layer 305. The heater wire 309 is laid out along the piecewise segments 302, 304 and the circular loop portion 306 in an analogous fashion to the wiring pattern shown fully in Fig. 2.

Amend paragraph no. 59 as follows:

59. The partial cut-away portion of the view (in the upper right quadrant) shows the top layer of foam insulation 407 stripped away to expose the heater wire 409 resting on the bottom, supporting layer 405. The heater wire 409 is laid out along the circular loop portion and 406 the radially aligned piecewise segments 402 in an analogous fashion to the wiring pattern shown fully in Fig. 2.

Amend paragraph no. 61 as follows:

61. The partial cut-away portion of the view (on the right side) shows the top layer of foam insulation 527 stripped away to expose the heater wire 529 resting on the bottom, supporting layer 525. The heater wire 529 is laid out along the piecewise segments 522, 524 and the semi-circular portion 526 in an analogous fashion to the wiring pattern shown fully in Fig. 2.

Amend paragraphs nos. 66 and 67 as follows:

66. Fig. 6 also illustrates (in phantom) an aspect of the present invention that is optional for incorporation into any of the embodiments. The [voltage distribution electrodes] Faraday

shields (i.e., heater assembly [substrates] supporting layers) according the various embodiments are optionally connectable to ground through a variable impedance 620. The shielding properties of the [voltage distribution electrode] Faraday shield can be manipulated by varying the value of the variable impedance 620.

67. Referring to Fig. 7, a cross-sectional detail view of an electrical heating assembly, according to various embodiments of the present invention, disposed on a dielectric lid of a vacuum chamber is illustrated. The bottom, supporting layer 710 of the heating assembly according to the resistive heating embodiments is preferably constructed as a Faraday shield from anodized aluminum, but can be suitably constructed from any material that has good thermal conductivity (e.g., aluminum or copper). The [bottom layer] Faraday shield 710 is placed in direct contact with the dielectric lid 720 so as to provide good thermal communication therewith. The resistive heater wire segments 730, 731 (formed from material such as Nichrome wire) are attached to the [bottom layer] Faraday shield 710 without being electrically connected thereto and are wound along the radial segments and connective circular loop (refer to Figs. 2 to 5) in a manner which maximizes the electromagnetic resistance (i.e., impedance)

of the overall heater wire circuit to the electromagnetic fields produced by the coil. The heater supply current flows in opposite directions in the adjacent wire segments 730, 731. That is to say, the current flows into the page for one segment 730 and out of page for its adjacent segment 731, for example.

Amend paragraphs nos. 69-71 as follows:

69. A layer of thermal insulating material 740 (preferably foamed polymer) is placed on the surfaces of the heater wire 730 and may extend over the [bottom layer] Faraday shield 710. This insulating material layer 740 improves the efficiency of the heating assembly by minimizing heat losses to the ambient air. This insulation is particularly helpful for the embodiments that utilize forced air convection in order to remove excess heat from the outer (i.e., top) surface of the dielectric lid 720.

70. The electrical heating assembly is optionally secured to the lid 720 by a mechanical clamp 750 (shown in phantom) or is secured by an adhesive bond between the lid 720 and the [bottom layer] Faraday shield 710 by a heat conductive epoxy. If the RF coil is sufficiently heavy, then the weight of the RF coil alone, resting on the electrical heating assembly, can be used to secure the electrical heating assembly to the top of the lid 720.

71. Also shown in phantom is an optional variable impedance 760 connectable between the [bottom layer] Faraday shield 710 and ground potential. The shielding properties of the [bottom layer] Faraday shield 710 can be manipulated by varying the value of the variable impedance 760.

Amend paragraph no. 78 as follows:

78. In this alternate embodiment, a heating assembly (a heating element 1130 in combination with a [conductive substrate] Faraday shield 1140 formed as a conductive supporting layer) is placed between the RF coil 1120 and the atmospheric side of the dielectric lid 1112. The RF coil 1120 couples energy into the vacuum chamber 1110 to thereby excite the process gases inside the chamber into a plasma state. The heating assembly according to this embodiment includes a [conductive substrate] Faraday shield 1140 that is disposed between the lid 1112 and the electrical heating element portion 1130 of the heating assembly. The [conductive substrate] Faraday shield 1140 has one or more fluid conduits formed therein to convey thermal working fluid to and from a temperature regulated fluid reservoir. The [conductive substrate] Faraday shield 1140 is either permitted to float, or is optionally connected to ground via a variable

impedance.

Amend paragraphs nos. 82-89 as follows:

82. Referring to Fig. 12, a cross-sectional detail view of an electrical heating assembly, according to the embodiment of Fig. 11 is illustrated. The [conductive bottom layer (or substrate)] Faraday shield 1210 is placed in direct contact with the dielectric lid 1120 so as to provide good thermal communication therewith. The resistive heater wire segments 1230, 1231 are attached to the [bottom layer] Faraday shield 1210 without being electrically connected thereto and are wound along the radial segments and connective circular loop (refer to Figs. 2 to 5) in a manner which maximizes the electromagnetic resistance (i.e., impedance) of the overall heater wire circuit to the electromagnetic fields produced by the coil. The heater supply current flows in opposite directions in the adjacent wire segments 1230, 1231.

83. The heating assembly incorporates a pair of fluid channels 1262, 1264 in tandem with one another within the structure of the radial segments and the connecting arcuate segments of the [conductive bottom layer] Faraday shield 1210. A thermal working fluid 1266, provided from a temperature

controlled fluid reservoir, is forced in a first direction through one fluid channel 1262 and in an opposite direction through the adjacent channel 1264. The working fluid 1266 provides for heat to be exchanged between the reservoir and the dielectric lid 1220.

84. A layer of thermal insulating material 1240 is placed on the surfaces of the heater wire segments 1230, 1231 and may extend over the [bottom layer] Faraday shield 1210. This insulating material layer 1240 improves the efficiency of the heating assembly by minimizing heat losses to the ambient air. This insulation is particularly helpful for the embodiments that utilize forced air convection in order to remove excess heat from the outer (i.e., top) surface of the dielectric lid 1220.

85. The electrical heating assembly is optionally secured to the lid 1220 by a mechanical clamp 1250 (shown in phantom) or is secured by an adhesive bond between the lid 1220 and the [bottom layer] Faraday shield 1210 by a heat conductive epoxy.

86. The embodiment illustrated by Figs. 11 and 12 has plural operational modes. In a first operational mode, the working fluid is heated in the fluid reservoir to a temperature above ambient and functions to smooth out thermal transients. Thermal transients arise due to the sudden step changes caused when the

electrical heating element is energized and de-energized or when the fan 1150 is turned on and off (if the fan is incorporated). The constant flow of heated fluid in the channels 1262, 1264 of the [conductive bottom layer] Faraday shield 1210 serves as a stabilizing influence.

87. According to a second operational mode, the working fluid is cooled in the fluid reservoir so that it may serve as a mechanism for removing heat from the lid 1220. In this operational mode the [conductive bottom layer] Faraday shield 1210 itself serves as a cooling device in place of the fan 1150.

88. Of course, in the case of either of these operating modes, the [conductive bottom layer] Faraday shield 1210 continues to function to distribute electric potential evenly across the lid 1220 and, when grounded, to act as a shield.

89. Another feature of the invention is that it maintains a more uniform electromagnetic potential across the dielectric lid. The bottom, supporting layer of the heating assembly (alternatively, the conductive conduit in the fluid embodiments) forms a [voltage distribution electrode] Faraday shield that develops an electromagnetic potential that is approximately equal to the spatially average potential determined over the entire area defined by the heating assembly. Thus, although the active heating structure (either the resistive heating wire or the

thermal working fluid) portion of the heating assembly is transparent to the electromagnetic fields produced by the coil that penetrate the dielectric lid and generate the plasma, the conductive portion of the heating assembly takes on the role of shaping the electric potential produced by the coil. The result of this averaging is the minimization of detrimental effects of electromagnetic potentials that are too high (e.g., sputtering of the dielectric by the plasma) and of electromagnetic potentials that are too low (e.g., heavy by-product depositions on the dielectric lid). The simultaneous control of both the temperature of the dielectric lid and the electrostatic potential in the region directly adjacent to the lid produces conditions that are very favorable for achieving the desired plasma process results on the workpiece.

IN THE CLAIMS:

Amend claims 1, 4-6, 14, 17, 28, 33, and 37 as follows:

1. (Once Amended) In combination, a heating element, a [voltage distribution electrode] Faraday shield, and a semiconductor processing chamber, the semiconductor processing chamber comprising:

a wafer support disposed inside the chamber,

a gas delivery channel disposed in the chamber to

deliver gas adjacent the wafer support, and a chamber wall, the chamber wall being in thermal contact with the heating element; wherein the [voltage distribution electrode] Faraday shield is disposed [adjacent] between the heating element and the chamber wall.

4. (Once Amended) The combination of claim 1, wherein the [voltage distribution electrode] Faraday shield has a circular shape.

5. (Once Amended) The combination of claim 4, wherein the [voltage distribution electrode] Faraday shield comprises: a circular loop; and radial segments connected together by the circular loop.

6. (Once Amended) A temperature management apparatus for promoting thermal uniformity for a chamber wall, the apparatus comprising:

a [substrate] Faraday shield having a predetermined shape and having edges; a resistive heating element [disposed on the substrate] layered over the Faraday shield adjacent to the edges of the [substrate] Faraday shield;

wherein the [substrate] Faraday shield is [adapted to provide] electrically isolated from the resistive heating element and provides thermal communication [with] from the resistive heating element to the chamber wall.

14. (Once Amended) The temperature management apparatus of claim 13, wherein the predetermined shape comprises plural radial elements and a circular element, disposed at the [periphery of the substrate] outer edge of the substrate, joining the plural radial elements together.

17. (Once Amended) The temperature management apparatus of claim 13, wherein the predetermined shape comprises plural radial elements and a circular element, disposed near the center of the [substrate] Faraday shield, joining the plural radial elements together.

28. (Once Amended) An apparatus for processing a semiconductor wafer comprising:

a vacuum chamber adapted to receive the semiconductor wafer therein, the vacuum chamber having a chamber wall; [and]

[a temperature management apparatus comprising:]

a heater disposed outside of the vacuum chamber in thermal contact with the chamber wall; [, and]

[a source of air flow disposed near the dielectric wall to remove excess heat energy]

an RF coil disposed adjacent to the vacuum chamber so as to couple RF energy into the vacuum chamber, the heater being disposed between the RF coil and the chamber wall; and

a Faraday shield having variable shielding efficiency, the shield being disposed between the heater and the chamber wall.

33. (Once Amended) The apparatus for processing a semiconductor wafer of claim [32] 28, wherein the heater is substantially electrically transparent to the RF energy coupled into the chamber.

37. (Once Amended) The apparatus for processing a semiconductor wafer of claim [28] 39, wherein the source of air flow comprises a fan.